US008161786B2

(12) **United States Patent**
Stapleton

(10) **Patent No.:** **US 8,161,786 B2**
(45) **Date of Patent:** **Apr. 24, 2012**

(54) **APPARATUS FOR FEEDING AND TURNING TUBE PRODUCTS INTO A PILGER MILL MACHINE**

(76) Inventor: **Glen Stapleton**, Carlsbad, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 843 days.

(21) Appl. No.: **12/235,813**

(22) Filed: **Sep. 23, 2008**

(65) **Prior Publication Data**

US 2009/0255312 A1 Oct. 15, 2009

Related U.S. Application Data

(60) Provisional application No. 61/045,102, filed on Apr. 15, 2008.

(51) **Int. Cl.**
B21B 39/20 (2006.01)
B65H 20/00 (2006.01)

(52) **U.S. Cl.** **72/251**; 72/428; 72/95; 226/172

(58) **Field of Classification Search** 72/214, 72/249, 251, 244, 245, 422, 426, 428, 449, 72/257, 95, 77, 78; 226/171, 172
See application file for complete search history.

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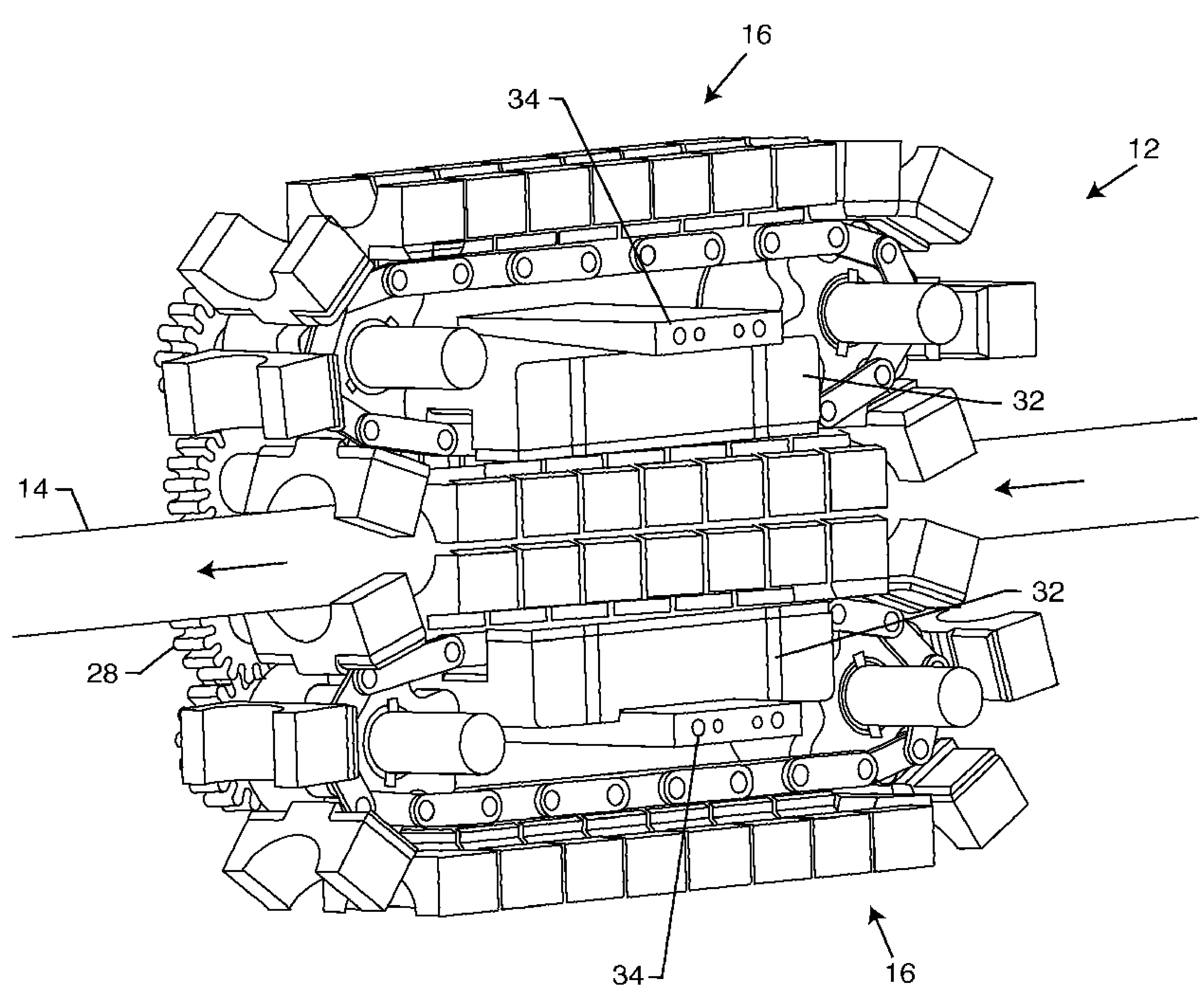
Primary Examiner — Debra Sullivan

(74) *Attorney, Agent, or Firm* — Kelly & Kelley, LLP

(57) **ABSTRACT**

Incoming tubes are turned and fed into a pilger mill by use of a single gearbox using a rotating dual track drive system. The dual track system holds the incoming tube while tube reducing (metal tube forming) occurs by the pilger tooling. When the pilger tooling is free of the incoming tube product, the dual track drive moves the tube into the pilger tooling by feeding an incremental amount of tube product. The dual track drive also indexes the incoming tube at the correct time and at a pre-determined amount. Additionally, the gearbox sub-assembly bumps the tube at a pre-determined time while the tube is free from the tooling.

21 Claims, 11 Drawing Sheets



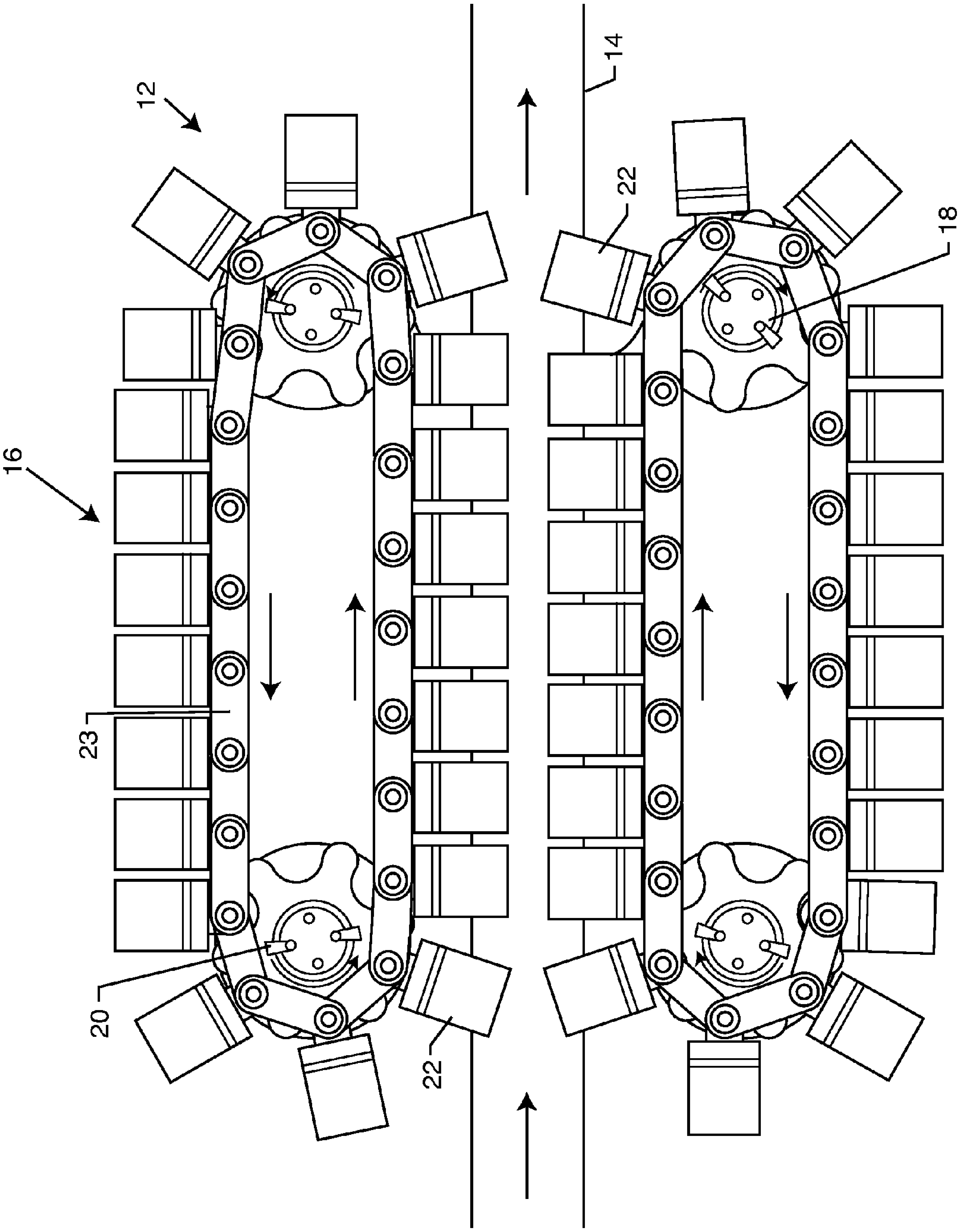


FIG. 1

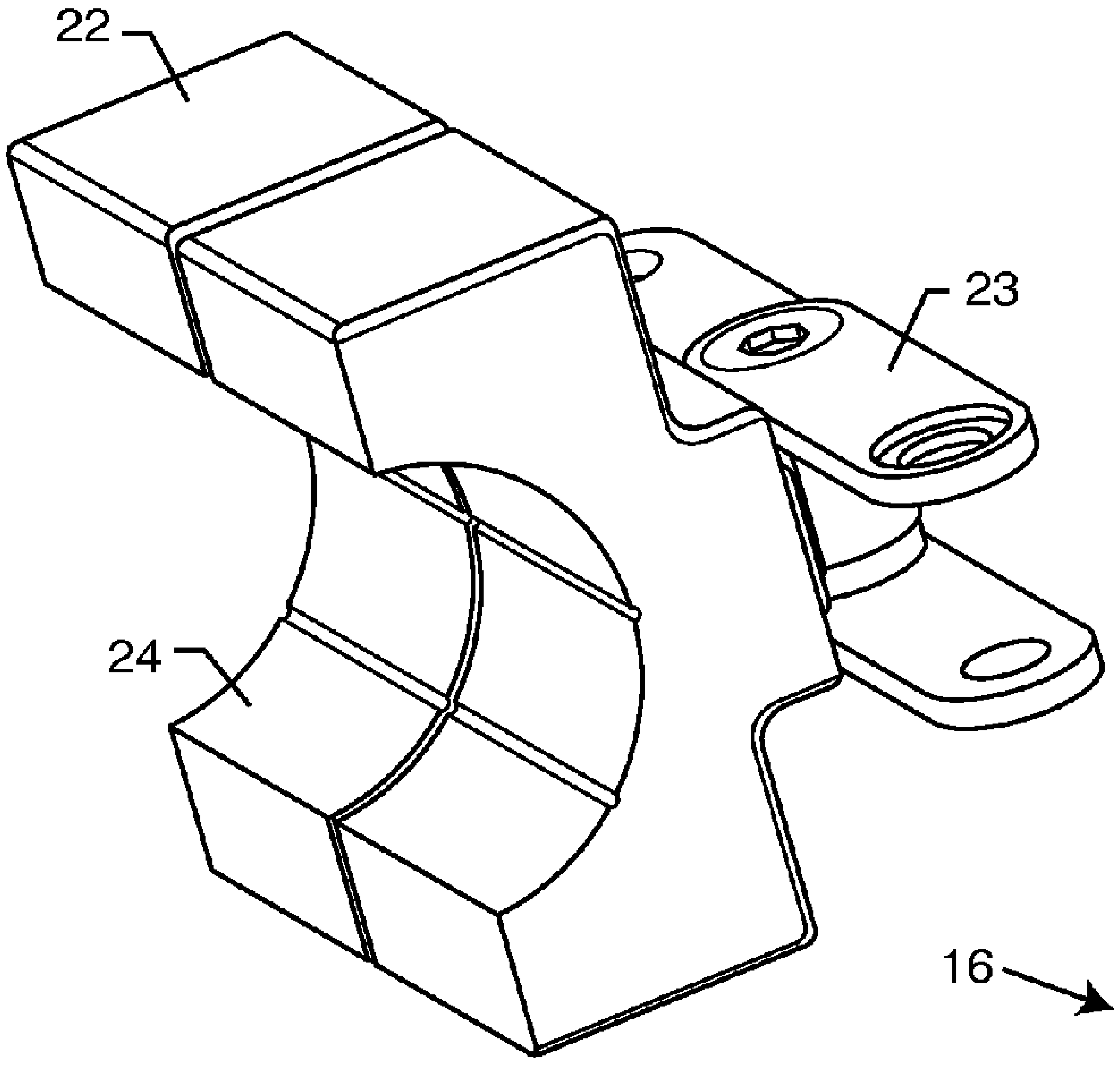


FIG. 2

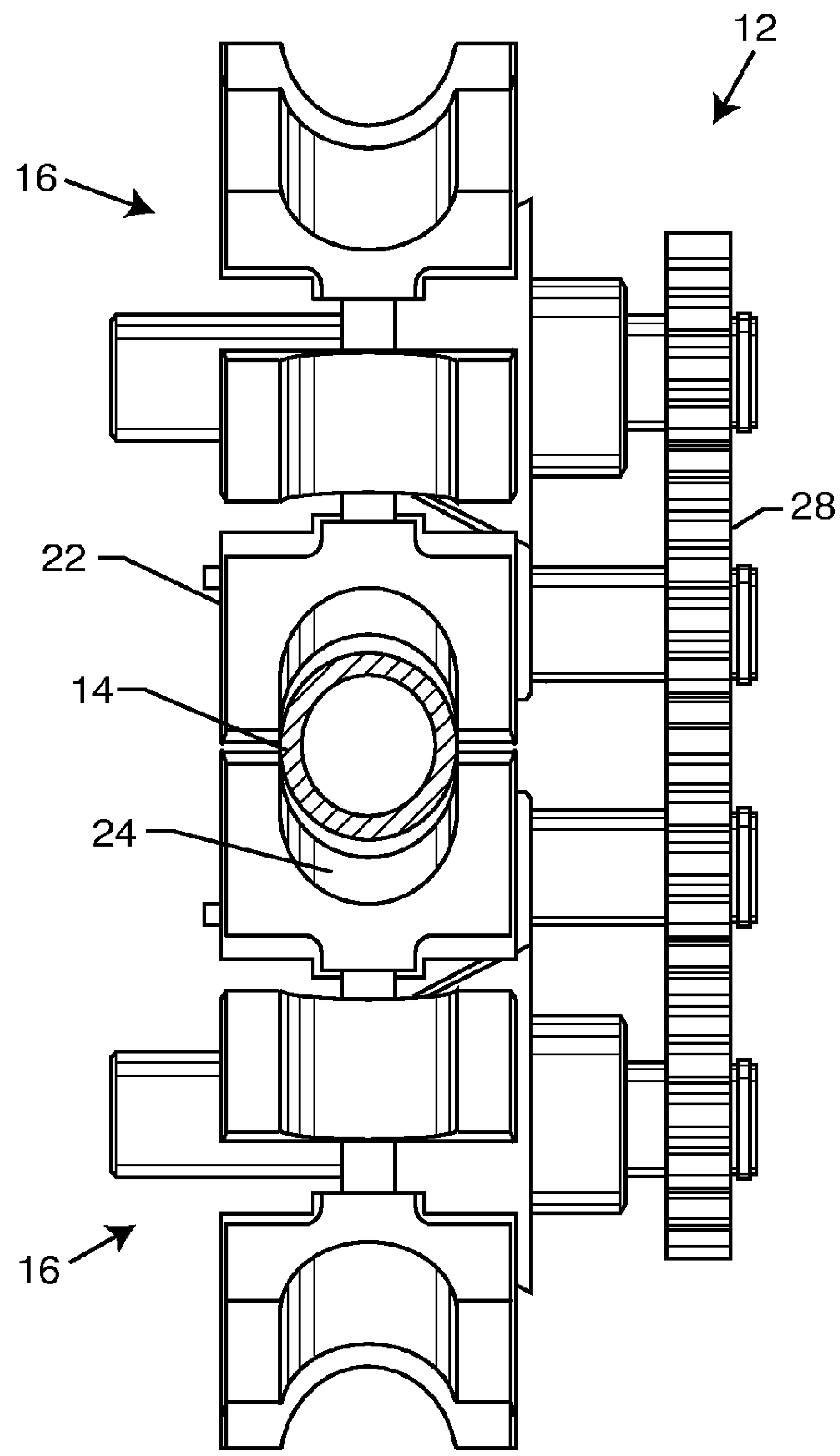


FIG. 3

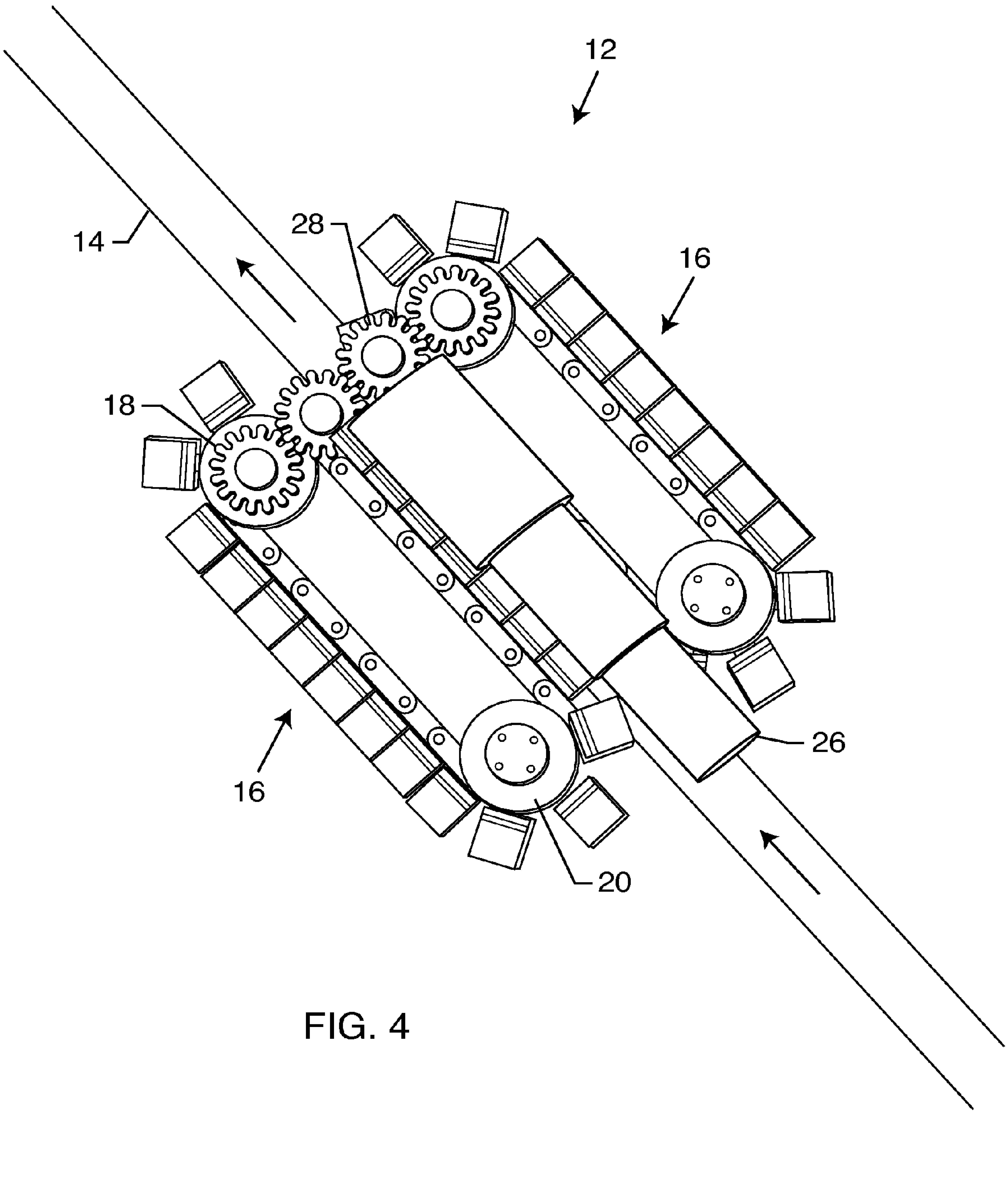


FIG. 4

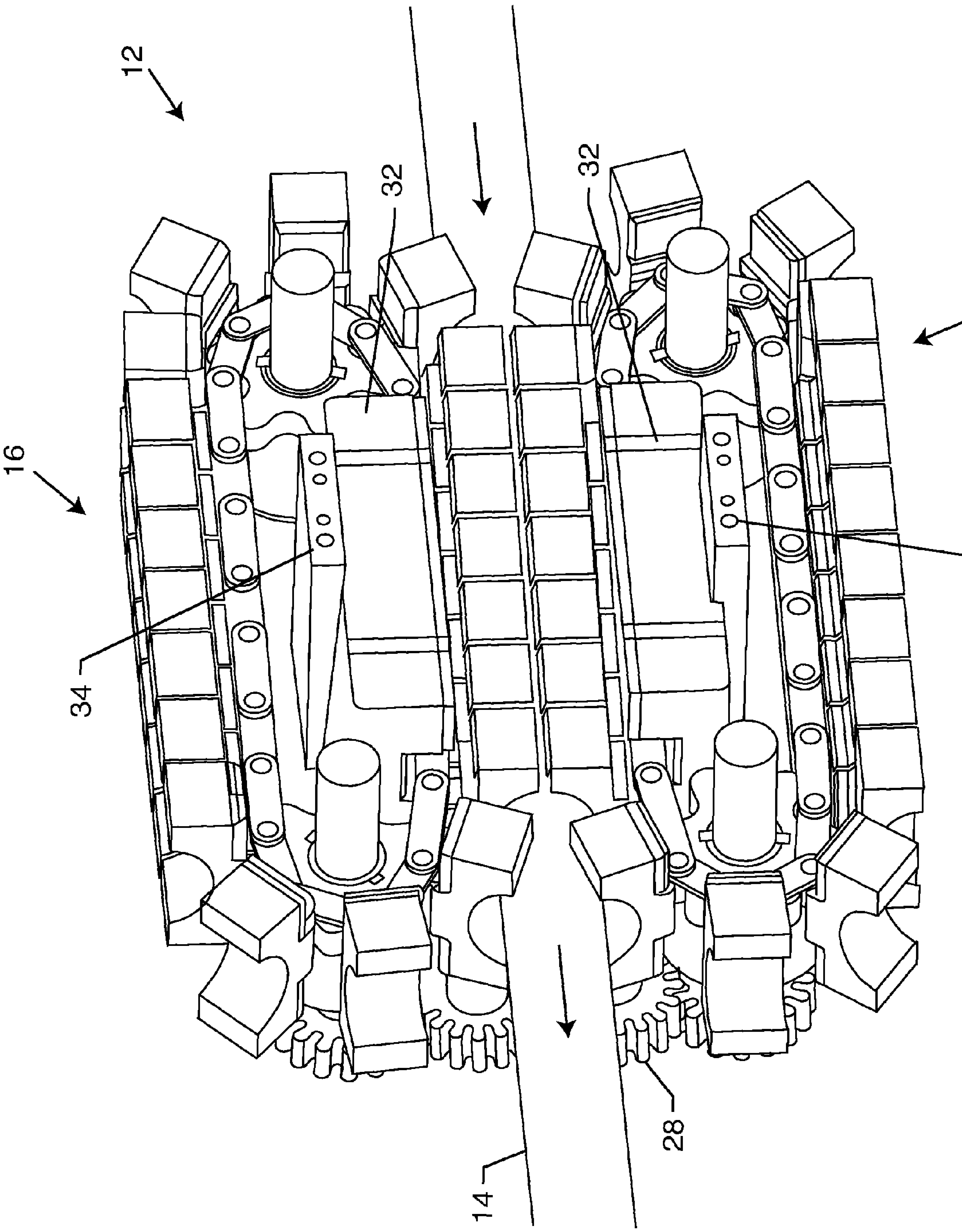


FIG. 5

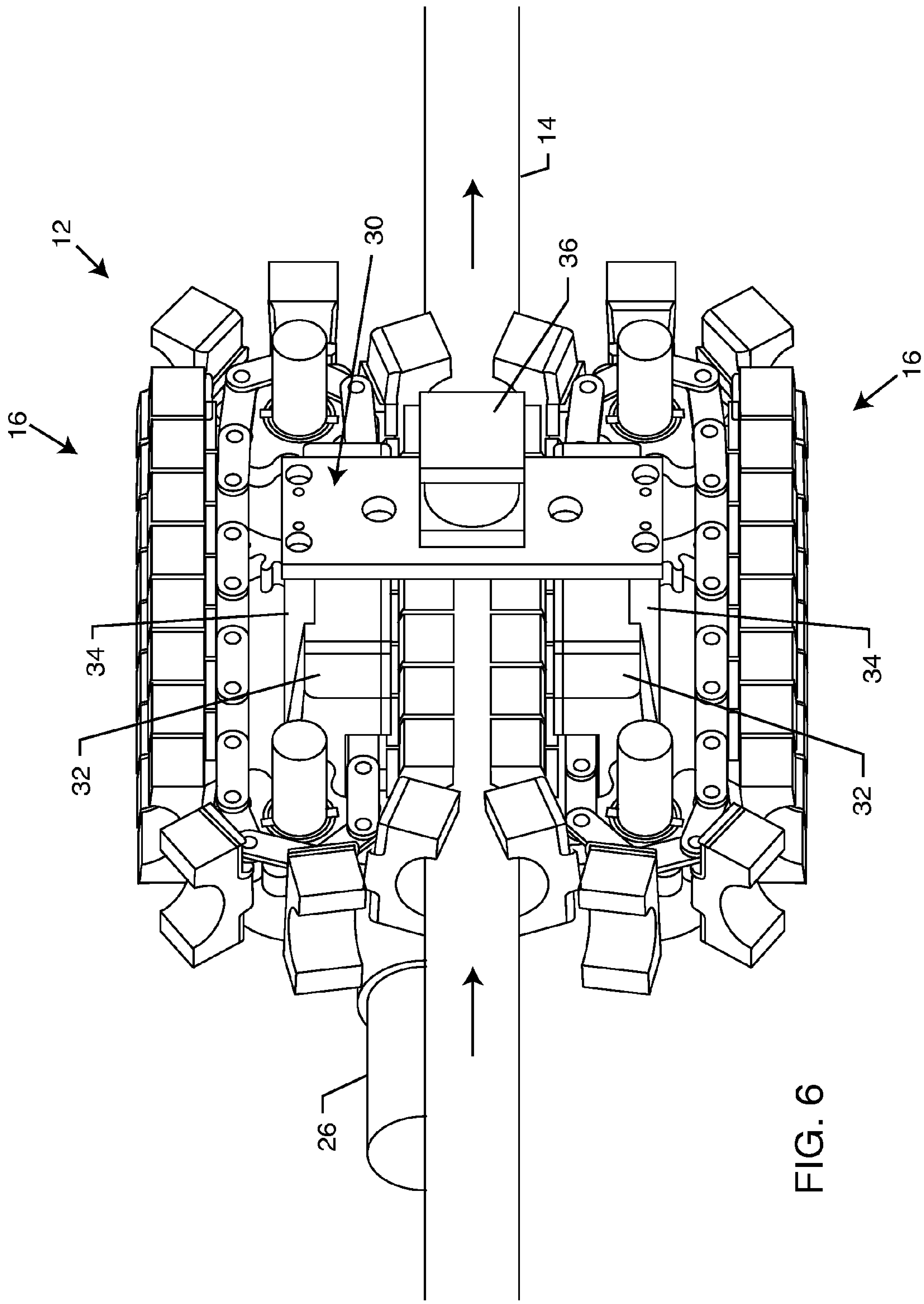


FIG. 6

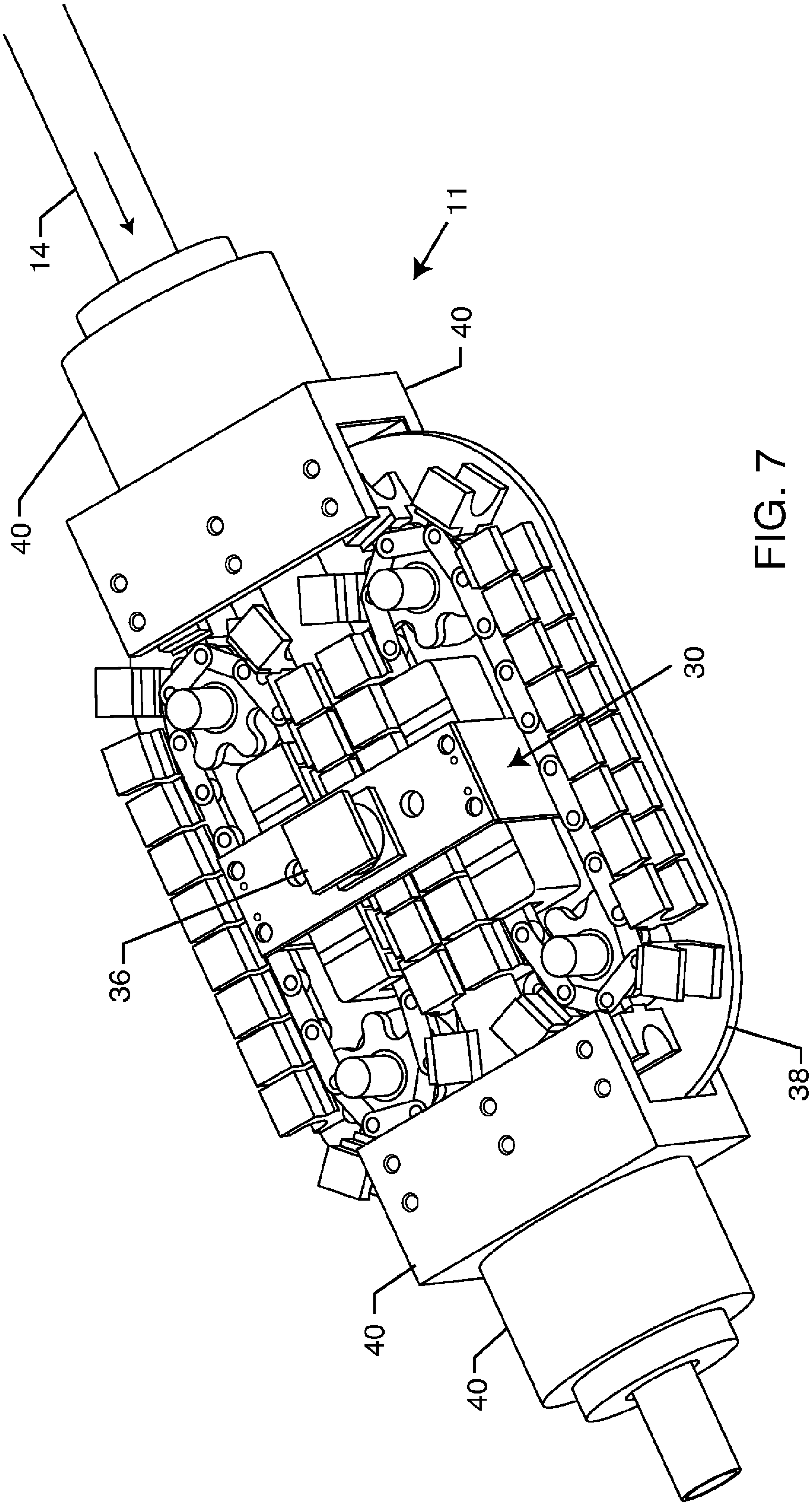


FIG. 7

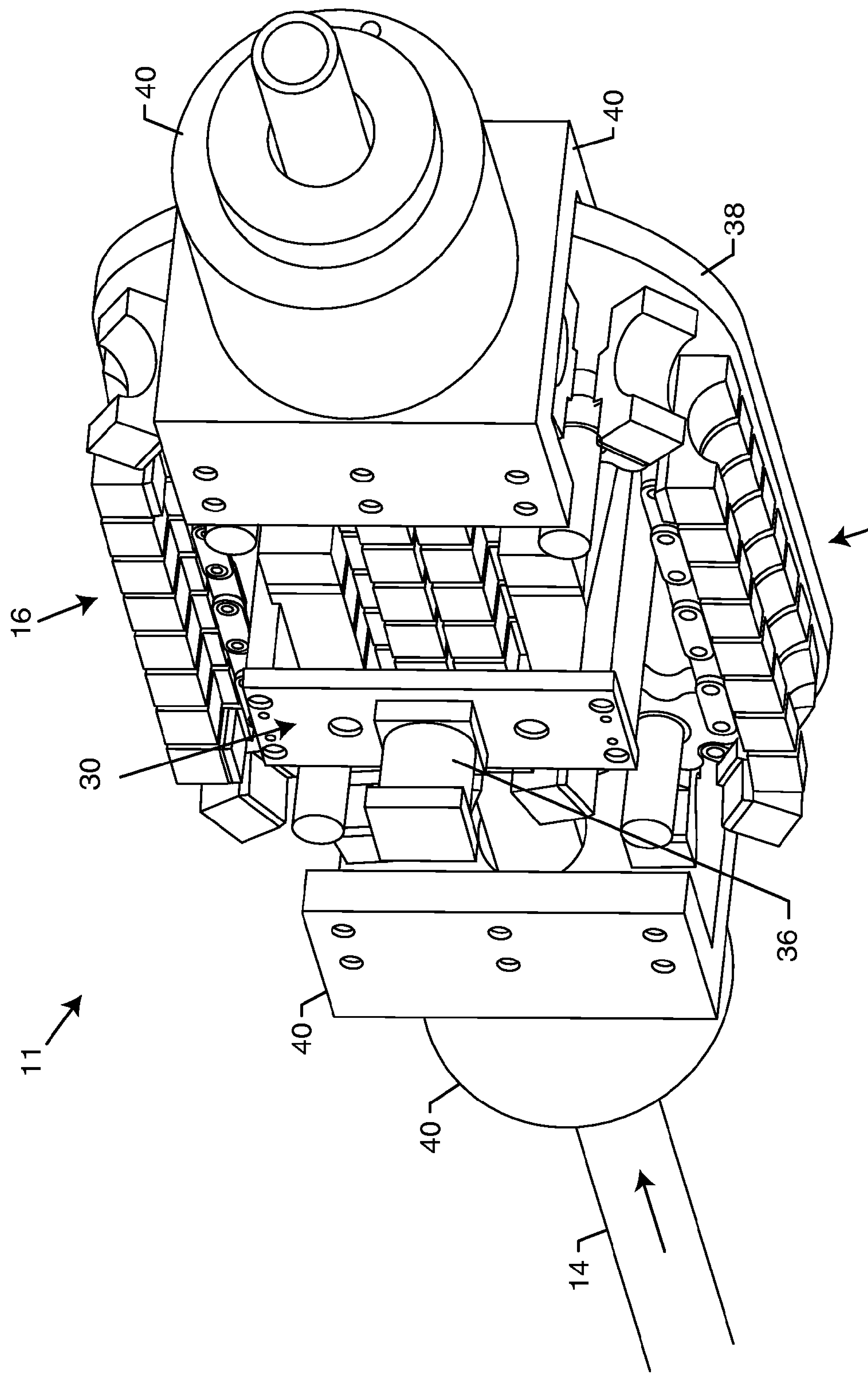


FIG. 8

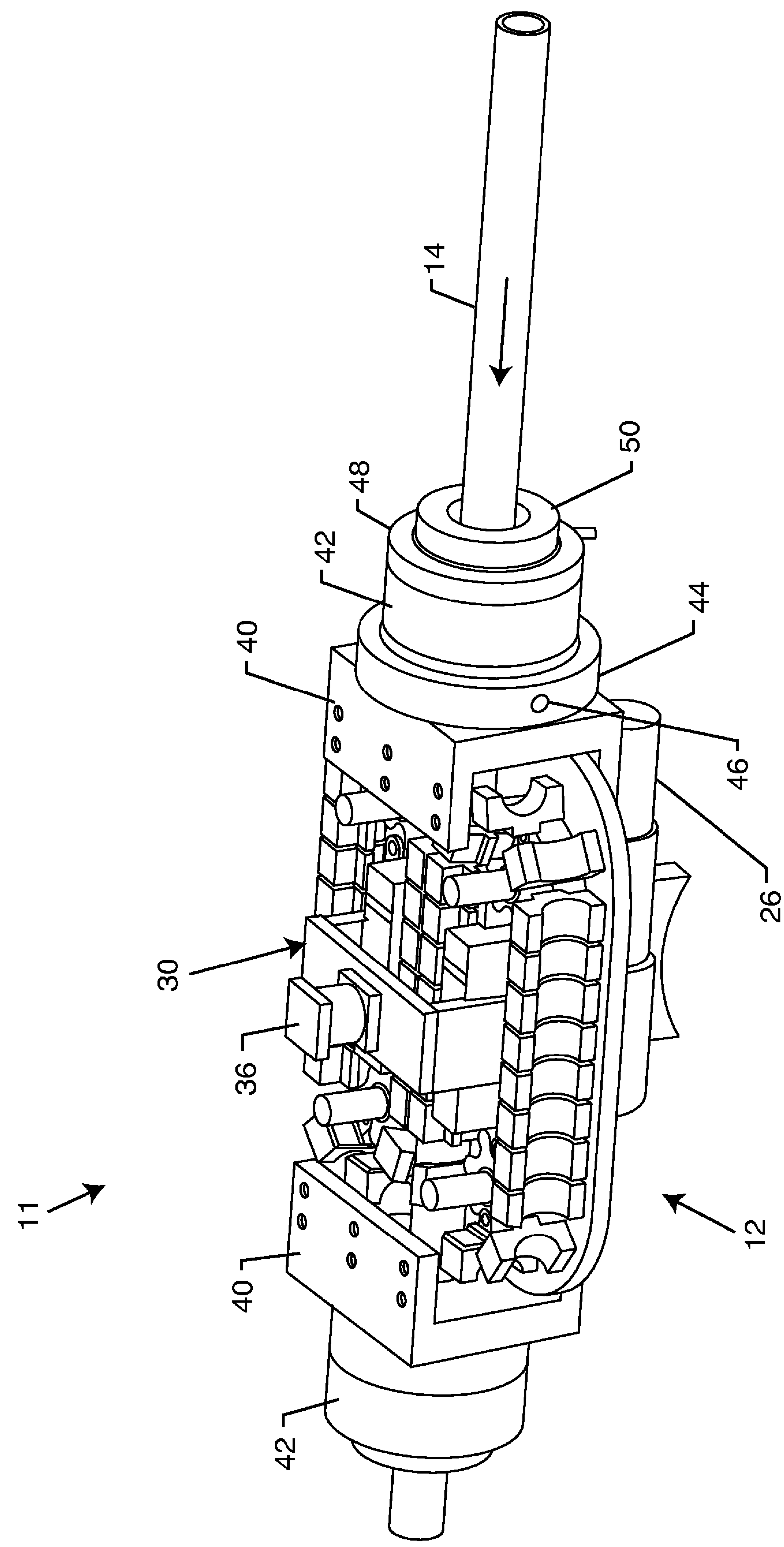


FIG. 9

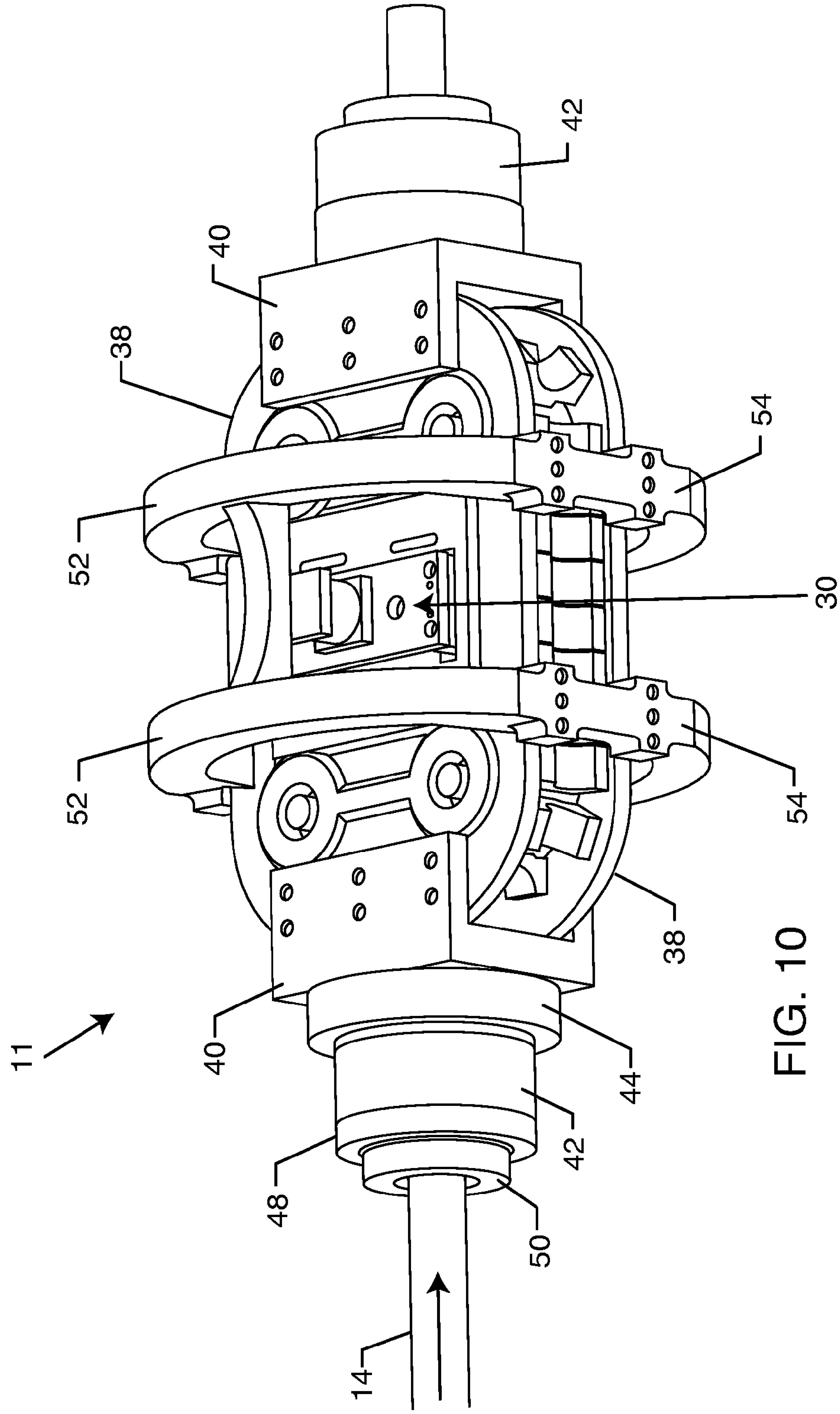


FIG. 10

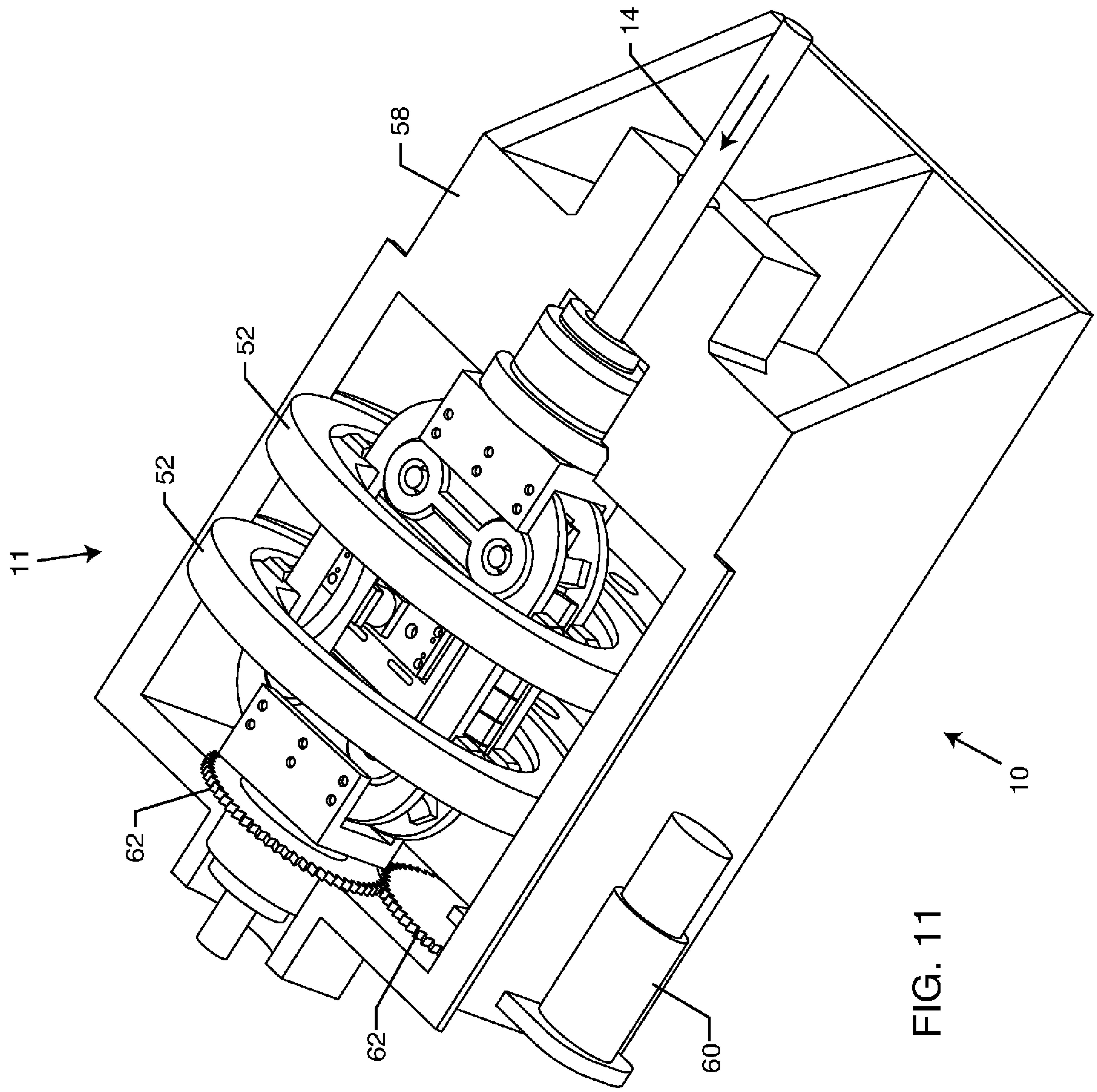


FIG. 11

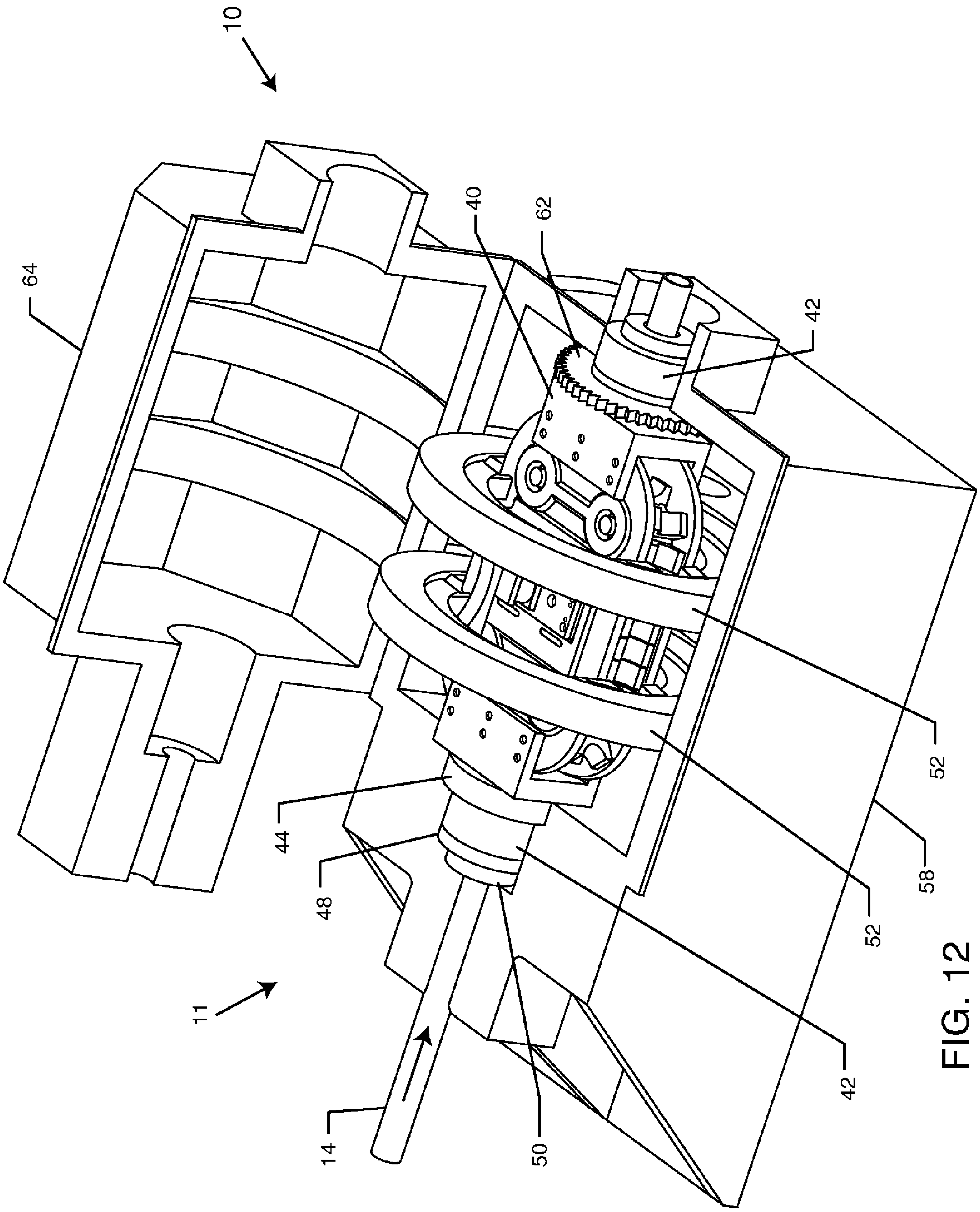


FIG. 12

APPARATUS FOR FEEDING AND TURNING TUBE PRODUCTS INTO A PILGER MILL MACHINE

BACKGROUND OF THE INVENTION

One of the existing methods of producing medium to large quantities of metal tubing is through the use of pilger mills, also known as tube reducers. Another method to produce metal tubing is cold drawing but it is typically only used for small quantities of tubing. Pilger mill machines have been producing metal tubing since 1880 and are considered to be an efficient manufacturing process for significant quantities. The fundamental methods to form tubing from the pilger mill is with the use of an upper and lower die, rolling back and forth over a mandrel. This method was established in 1880 by the Mannesmann brothers of Germany when they patented a hot working of tubes.

In 1896, an American engineer patented the first cold pilger mill. The process principle has not changed since then but the supporting mechanisms have changed over the years many times. Many patents have been issued using new technology to support the same pilger principle. As the pilger principles utilize tooling to reduce the tube products, supporting mechanisms within the current day process are vital and crucial to the updated functions.

In general, each pilger machine has a major drive mechanism that provides a linear motion to the tooling, known as a stroke. Many of the machines in use today use a crankshaft for the linear movement. As the tooling consists of an upper & lower die that rolls back and forth over the tube product. A stationary rotating mandrel is located within the tube inside diameter.

Both top & bottom dies have a pre-shaped groove which forms or re-shapes the tube product smaller on each stroke. As the top & bottom dies form the outside diameter of the tube to a smaller size, the mandrel and the dies together also work the tube wall into a smaller size. As the dies roll back & forth, the tube product is fed into the dies and over the stationary rotating mandrel. While the tube is reduced in size of outside diameter and inside diameter, the tube also becomes elongated.

The supporting mechanisms that provide the vital functions on today's pilger mills are done thru the use of various gearboxes. All of these current gearboxes provide 3 basic functions directly to the incoming tube for the typical pilger process. They provide tube turning (or indexing), incremental feeding, and bumping of the incoming tube over the rotating mandrel. The stationary mandrel rotation is also provided by two of the gearboxes and is mechanically driven from within the gearboxes.

Current pilger mill machines perform these three functions, along with pilgering (forming) the tube, for a continuous operation. A continuous operation means that the pilger machine operates without stopping the machine to load new incoming tubes. Older generations of pilger mills have to stop and load one tube and then operate for that one tube, then stop to load the next incoming tube.

As a continuous pilger mill operation, many of these machines have 4 gearboxes that service the previously mentioned functions, turning, feeding and bumping. One gearbox, referred to as an upper gear train gearbox, transfers the rotary motion from a crankshaft, or other rotary drive, to three other gearboxes via a line shaft mechanism. A second gearbox, as driven by the line shaft, transfers the rotary motion into turning of the incoming tube and mandrel lock. The third gearbox, as driven by the line shaft, transfers the rotary motion into turning of the incoming tube. Also, this third gearbox provides feeding and bumping of the incoming tube as well as operating a mandrel lock. The forth gearbox, as driven by the line shaft, transfers the rotary motion into turning of the incoming tube. Also, this forth gearbox provides feeding of the incoming tube.

As described in U.S. Pat. No. 5,035,132 by Josef Gerretz, multiple gearboxes were used in order to achieve a continuous operation of the pilger mill. These multiple gearboxes provided the necessary feeding and turning of the incoming tubes. Other related patents enhance this continuous mill operation. The disadvantage to this patent is that it does not perform any of the necessary bumping of the tube products which is very important to many of the pilger processes. Also, this patent fails to describe how the device grips the tube product.

As described in U.S. Pat. No. 6,257,040, by Michael Beansch, Wolfgang Ernhardt, Bernhard Gromada, Ernst Holler, Horst Mattes, the inventors replaced the older mechanical drives of the 1960s with updated technology. The improved controls of the hydraulic drives, are an improvement to the pilger process. These drives still provide the same necessary feeding and turning of the incoming tubes in all of the gearboxes. The disadvantage of this patent effort is it still requires multiple gearboxes.

Other related patents continue to promote or enhance the continuous pilger mill operation using two or more gearboxes to support the necessary feeding & turning of the tube into the pilger tooling. The disadvantage of the use of multiple gearboxes is the large cost of operation and maintenance that is required to maintain the necessary supporting functions of feeding & turning. A large percentage of the initial cost of investment into a pilger mill is in the complex gearboxes. Also, the maintenance cost of two or four gearboxes is staggering over time as the machine experiences normal wear.

Accordingly, there is a need for a pilger mill device that performs the necessary functions of indexing, feeding, bumping and mandrel rotation with fewer gearboxes. The present invention satisfies this need and provides other related advantages.

SUMMARY OF THE INVENTION

The present invention allows the necessary pilger mill supporting functions of feeding, turning and bumping to be performed in one gearbox only, therefore replacing anywhere from two to four gearboxes in prior art devices. The cost savings on the initial machine investment, as well as the saving on the long term maintenance of the gearboxes is extremely large.

The present invention is directed to a single gearbox for providing feed, index and bump motion of tube product in a pilger mill. The gearbox includes a sub-assembly that comprises a track drive including a linearly rotating track for feeding the tube product along a longitudinal axis of the sub-assembly. The sub-assembly also includes an end support attached to an end thereof for rotating the sub-assembly about the longitudinal axis, thereby indexing the tube product. The sub-assembly also includes a hydraulic ring cylinder attached to an end thereof for shifting the sub-assembly along the longitudinal axis, thereby bumping the tube product.

The track drive comprises a dual track drive having two linearly rotating tracks, wherein each track is comprised of a looped series of segmented clamps contoured to the shape of the tube product. The track drive further includes a slide-wedge assembly for forcing a portion of the linearly rotating track against the tube product. With two linearly rotating tracks, the slide-wedge assembly forces opposing portions of the tracks against the tube product. The end support may comprise a pair of end supports attached to opposite ends of the sub-assembly. Further, a rotary union is attached to an end of the sub-assembly for providing a point of connection for an external pneumatic or hydraulic source to the sub-assembly. The pneumatic or hydraulic source being for actuating a cylinder acting on the slide-wedge assembly.

An electrical slip ring is attached to an end of the sub-assembly for providing a point of connection for an external electrical source to the sub-assembly. The electrical source for powering a servo motor acting on the track drive. A ring bearing is disposed proximate to a longitudinal midpoint of the sub-assembly, the ring bearing being operatively connected to a gearbox casing to facilitate rotating of the sub-assembly about the longitudinal axis. The ring bearing may comprise a pair of ring bearings uniformly spaced about the longitudinal midpoint of the sub-assembly. Further, a servo drive may be included on the gearbox casing for acting on the end support to rotate the sub-assembly.

Other features and advantages of the present invention will become apparent from the following more detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate the invention. In such drawings:

FIG. **1** illustrates the dual track drive of the present invention;

FIG. **2** illustrates one of the segmented clamps of the dual track drive;

FIG. **3** is an end view of the dual track drive of the present invention;

FIG. **4** shows the dual track drive with the servo drive motor and transfer gears on drive and idler shafts;

FIG. **5** shows the dual track drive with the slide-wedge assembly in each of the linearly rotating tracks;

FIG. **6** shows the pneumatic or hydraulic cylinder to actuate slide-wedge assembly on the dual track drive;

FIG. **7** shows the end supports and the base plate on the sub-assembly of the present invention;

FIG. **8** shows the end supports and the base plate on the sub-assembly of the present invention;

FIG. **9** shows the end supports with the rotary union, the electrical slip ring and hydraulic ring cylinder;

FIG. **10** shows the mounting of two ring bearings and the upper base plate on the sub-assembly;

FIG. **11** illustrates how the use of ring bearings facilitate the rotation of the sub-assembly in the gearbox casing; and

FIG. **12** shows the sub-assembly mounted in the complete gearbox casing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in the accompanying drawings, for purposes of illustration, the present invention is directed to a new device for feeding and turning metal tube products within a tube reducer or pilger mill. For ease of understanding, the drawings illustrate the piecewise assembly of the inventive gearbox, generally referred to by reference numeral **10**. This described "assembly" of the gearbox **10** is only for purposes of describing a sub-assembly **11** and is not intended to limit the manner in which the gearbox **10** is manufactured.

The inventive gearbox **10** includes a dual track drive **12** that is more efficient and provides quality delivery of metal tube product **14** to the tooling of a pilger mill or tube reducing machine (not shown). The gearbox **10** provides for a continuous machine operation without work stoppage. The feeding and turning functions of the gearbox **10** are both infinitely adjustable with the use of computer controls to variable drive motors. The inventive device results in a reduction of the number of gearboxes needed to perform the task of feeding and turning the incoming tube **14** to the pilger mill tooling. Comparatively, for prior art pilger mill machines that perform the same functions, the number of gearboxes is reduced from three or four gearboxes to only one gearbox.

FIG. **1** shows the dual track drive **12** and how the motion of a dual track system feeds a tube in a forward direction (arrows) towards the pilger mill. Preferably, the dual track drive **12** includes two linearly rotating tracks **16** positioned opposite one another. However, the track drive **12** may include only a single track **16** positioned opposite a surface that permits the tube product to slide thereon, i.e., essentially frictionless. Each track **16** has a drive sprocket **18** which drives the track **16**. An idler sprocket **20** is also used to complete the circular motion of the track **16**. The track **16** consists of a plurality of segmented or individual clamps **22**, as illustrated in FIG. **2**, joined in a loop by linkage and pins **23** which have the same or similar shape or contour **24** as the metal tube product **14**.

FIG. **3** shows an end view of the dual track drive **12** and the contour **24** of the track segments **22**. The segment contour **24** makes contact with the outside diameter of the tube **14** spanning approximately half of the tube circumference. Several sequential segments **22** of the track **16** are in contact with a linear section of the tube **14** in order to have a large amount of surface contact with the tube **14**. The segments **22** of the oppositely positioned tracks **16** surround the tube **14**, providing improved gripping.

A servo motor **26**, as shown in FIG. **4**, is used to provide power or rotational motion to the dual track drive **12**. The servo motor **26** rotates transfer gears **28**, which rotate the drive sprockets **18** and in turn move the tracks **16** and segments **22**. The tube product **14** is shown and the direction of the material flow within the track drive **12** is shown by the arrows. The motion of the track drive **12** may be stopped or held by a disk break (not shown) located inside or near the servo motor **26**. FIG. **4** clearly shows the drive sprockets **18** that are driven by the servo motor **26** and the idler sprockets **20** that complete the loop or circular motion of each of the two tracks **16**.

Within each of the tracks **16**, is a slide-wedge assembly **30** which forces contact of several opposing segments **22** of each of the tracks **16** to the tube product **14**. FIG. **5** shows the placement of the slide **32** and wedge **34** in each track **16**. Clamping of the tube product **14** is achieved through the use of linear motion, as provided from a cylinder **36** to the slide-wedge assembly **30**. As seen in FIG. **6**, as the cylinder **36** moves inward against the wedges **34**, the wedges **34** force each slide **32** against the adjacent segments **22**. This clamping movement from both slides **32** forces contact between the track segments **22** and the tube product **14**. Therefore, there is direct contact between the track drive segments **22** and the tube product **14** while the servo motor **26** turns the sprockets to rotate the tracks **16** and move the tube product **14** in the material flow direction. The slides **32** and segments **22** are configured such that one slides over the other even under the pressure exerted by the slide-wedge assembly **30**. The track drive segments **22** release the tube product **14** when the cylinder releases the wedge **34** and the force upon the slides **32** and the tube product **14**.

The track drive assembly **12** is mounted on two base plates **38**. For viewing purposes, only one plate **38** and how the assemblies are located on the plate is shown in FIGS. **7**, **8** and **9**. The second base plate **38** is positioned on the opposite side of the track drive **12** as shown in FIG. **10**. Also, as shown in FIGS. **7** and **8**, there are two end supports **40** mounted on each end of the plates **38**. The end supports **40** provide a mount for active components as described below.

FIG. **9** shows the sub-assembly **11** of the gearbox **10** without a housing (shown below). Support bearings **42** are mounted on the end supports **40** in order to allow for full 360 degree rotation of the sub-assembly **11**.

Also mounted on an end support **40** is a rotary union **44** providing pneumatic or hydraulic pressure to the gearbox **10**. The rotary union **44** allows for pressure to be transferred from a stationary, external source (not shown) to the rotating sub-assembly **11** upon which the cylinder **36** is mounted. As described, the cylinder **36** operates the slide-wedge assembly **30**. A hole **46** is provided in the rotary union **44** for a pneumatic or hydraulic line (not shown) to be attached and provide a source of pressure to the cylinder **36**.

Also mounted on an end support **40** is an electrical slip ring **48** which allows electrical current to be transmitted from a stationary, external source (not shown) to the rotating sub-assembly **11** upon which the servo motor **26** is mounted. As described, the servo motor **26** drives the track drive **12** of the sub-assembly **11**.

Also shown in FIG. **9**, is a hydraulic ring cylinder **50** that is mounted on an end support **40**. The hydraulic ring cylinder **50** provides small linear movement or bumping of the entire sub-assembly **11**. The amount of linear movement or bumping is adjustable and can be as much as ½ inch or nearly no movement at all. As described, bumping is used to release the tube product **14** from the tooling inside the pilger mill.

FIG. **10** shows the complete sub-assembly **11**, including both the top and bottom base plates **38**. Also shown are two ring supports **52** around the assembly **11** which allow the entire sub-assembly **11** to be mounted on bearings **54**. The bearings **54** are mounted to the ring supports **52**. With bearings **54** located on the two ring supports **52** and the two end supports **40**, the entire sub-assembly **11** is able to rotate in a nearly frictionless manner about a longitudinal axis coinciding with the tube product **14**. Each of these four main bearings **54** is fit within a bronze sleeve that allows the entire sub-assembly **11** to be bumped by the hydraulic ring cylinder **50**.

Alternatively, the ring supports **52** and related structures may be omitted and replaced by a plurality of stiffener bars. The stiffener bars run the length of the sub-assembly **11** and are positioned at the edges of the base plates **38**. The ends of the stiffener bars are attached to the end supports **40** and provide additional support to the entire sub-assembly **11**. With the ring supports **52** removed, the sub-assembly **11** rotates in the gearbox housing **58** solely upon the support bearings **42**. Such structure works best when the gearbox **10** is of a smaller design.

FIG. **11** shows how the sub-assembly **11** is mounted into the lower gearbox housing **58**. A servo drive **60**, used to rotate the entire sub-assembly **11**, is located on the outside of the lower housing **58**. The rotation of the servo drive **60** is transferred to the sub-assembly **11** by gears **62**. One gear **62** is mounted onto a end support **40** and a transfer gear is mounted on the housing **58** to transfer the rotary motion from the servo drive **60** to the sub-assembly **11**. A disc brake (not shown) mounted internally or externally of the servo drive **60**, is used to stop the rotation of the sub-assembly **11** when needed. FIG. **12** shows the completely assembled gearbox **10** with the upper housing **64** open so the sub-assembly **11** can be seen.

The inventive gearbox **10** is used to provide turning and feeding of incoming tube products **14** into the tooling of a pilger mill. The pilger mill reduces or works the incoming tube **14** into a smaller size both on outer diameter and inner diameter. For purposes of understanding, the function of a pilger mill is briefly explained.

As is common to pilger mills, this reduction of tube product **14** is accomplished by tooling of the pilger mill comprising a set of round dies and a mandrel. The outer diameter reduction of the incoming tube **14** is performed by dies which work the tube outer diameter when the dies rotate and travel. The incoming tube **14** inner diameter is formed by a mandrel while the dies reduce the tube outer diameter. The tube inner diameter and consequently the tube wall, is worked at the same time the tube outer diameter is reduced or formed.

As the tooling performs the work or the metal reduction, the rotation and travel of the tooling is controlled by a saddle. The saddle is moved back and forth by means of a mechanical drive, via a single crankshaft, or a bull gear system, or a multiple crank system, or a multiple gear system or other similar devices. The single back and forth movement of the saddle is described as one stroke. This functionality is separate from the feeding, turning and bumping of the gearbox **10** described above.

During the pilgering process, the incoming tube **14** is held or clamped in position momentarily by the gearbox **10** while the tooling reduces the tube product. After the pilger mill tooling has completed a stroke, the gearbox **10** incrementally moves the tube **14** forward a pre-determined amount, known as feeding. At the same time, the gearbox **10** indexes (rotates) the tube **14** a pre-determined amount. At the same time, the gearbox **10** bumps the tube **14** to release it from the mandrel.

The clamping or holding of the tube **14** is achieved by holding the dual track drive **12** stationary such that the segmented clamps **22** which are in contact with a portion of the tube **14** and compressed by the slide-wedge assembly **30**, as described above, securely hold the tube **14**. The feeding and turning, as described, may occur either at one or both end positions of the stroke of the saddle as it is mechanically moved. These end saddle positions are known in the art as entry and exit positions. The tooling is not reducing or in contact with the incoming tube **14** at either the entry or exit positions, therefore the tube **14** is free to be fed and indexed. After each feeding and indexing of the incoming tube **14**, the tooling resumes the reduction process again on each stroke.

Although an embodiment has been described in detail for purposes of illustration, various modifications may be made without departing from the scope and spirit of the invention. Accordingly, the invention is not to be limited, except as by the appended claims.

What is claimed is:

1. A single gearbox for providing feed, index and bump motion of tube product in a pilger mill, the gearbox including a sub-assembly comprising:

a track drive including a linearly rotating track for feeding the tube product along a longitudinal axis of the sub-assembly;

an end support attached to an end of the sub-assembly for rotating the sub-assembly about the longitudinal axis, thereby indexing the tube product; and

a hydraulic ring cylinder attached to an end of the sub-assembly for shifting the sub-assembly along the longitudinal axis, thereby bumping the tube product.

2. The single gearbox of claim **1**, wherein the track drive comprises a dual track drive having two linearly rotating tracks, wherein the linearly rotating tracks comprise a looped series of segmented clamps contoured to the shape of the tube product.

3. The single gearbox of claim **1**, wherein the end support comprises a pair of end supports attached to opposite ends of the sub-assembly.

4. The single gearbox of claim **1**, wherein the track drive further comprises a slide-wedge assembly for forcing a portion of the linearly rotating track against the tube product.

5. The single gearbox of claim **4**, further comprising a rotary union attached to an end of the sub-assembly, providing a point of connection for an external pneumatic or hydraulic source to the sub-assembly, the pneumatic or hydraulic source for actuating a cylinder acting on the slide-wedge assembly.

6. The single gearbox of claim **1**, further comprising an electrical slip ring attached to an end of the sub-assembly, providing a point of connection for an external electrical source to the sub-assembly, the electrical source for powering a servo motor acting on the track drive.

7. The single gearbox of claim **1**, further comprising a ring bearing disposed proximate to a longitudinal mid-point of the sub-assembly, the ring bearing operatively connected to a gearbox casing to facilitate rotating of the sub-assembly about the longitudinal axis.

8. The single gearbox of claim **7**, wherein the ring bearing comprises a pair of ring bearings uniformly spaced about the longitudinal mid-point of the sub-assembly.

9. The single gearbox of claim **7**, further comprising a servo drive on the gearbox casing for acting on the end support to rotate the sub-assembly.

10. A single gearbox for providing feed, index and bump motion of tube product in a pilger mill, the gear box including a sub-assembly comprising:

- a dual track drive including two linearly rotating tracks for feeding the tube product along a longitudinal axis of the sub-assembly;
- a pair of end support attached to opposite ends of the sub-assembly for rotating the sub-assembly about the longitudinal axis, thereby indexing the tube product; and
- a hydraulic ring cylinder attached to an end of the sub-assembly for shifting the sub-assembly along the longitudinal axis, thereby bumping the tube product.

11. The single gearbox of claim **10**, wherein the linearly rotating tracks comprise a looped series of segmented clamps contoured to the shape of the tube product.

12. The single gearbox of claim **10**, wherein the track drive further comprises a slide-wedge assembly for forcing opposing portions linearly rotating tracks against the tube product.

13. The single gearbox of claim **12**, further comprising a rotary union attached to an end of the sub-assembly, providing a point of connection for an external pneumatic or hydraulic source to the sub-assembly, the pneumatic of hydraulic source for actuating a cylinder acting on the slide-wedge assembly.

14. The single gearbox of claim **10**, further comprising an electrical slip ring attached to an end of the sub-assembly, providing a point of connection for an external electrical source to the sub-assembly, the electrical source for powering a servo motor acting on the track drive.

15. The single gearbox of claim **10**, further comprising a pair of ring bearings uniformly spaced about a longitudinal mid-point of the sub-assembly, the ring bearings operatively connected to a gearbox casing to facilitate rotating of the sub-assembly about the longitudinal axis.

16. The single gearbox of claim **15**, further comprising a servo drive on the gearbox casing for acting on gears and bearings in the end support to rotate the sub-assembly.

17. A single gearbox for providing feed, index and bump motion of tube product in a pilger mill, the gear box including a sub-assembly comprising:

- a dual track drive including two linearly rotating tracks comprising a looped series of segmented clamps for feeding the tube product along a longitudinal axis of the sub-assembly, and a slide-wedge assembly for forcing opposing series of the segmented clamps on each of the rotating tracks against the tube product;
- a pair of end supports attached to opposite ends of the sub-assembly for rotating the sub-assembly about the longitudinal axis, thereby indexing the tube product;
- a hydraulic ring cylinder attached to an end of the sub-assembly for shifting the sub-assembly along the longitudinal axis, thereby bumping the tube product; and
- a pair of ring bearings uniformly spaced about a longitudinal mid-point of the sub-assembly, the ring bearings operatively connected to a gearbox casing to facilitate rotating of the sub-assembly about the longitudinal axis.

18. The single gearbox of claim **17**, wherein the segmented clamps are contoured to the shape of the tube product.

19. The single gearbox of claim **17**, further comprising a rotary union attached to an end of the sub-assembly, providing a point of connection for an external pneumatic or hydraulic source to the sub-assembly, the pneumatic of hydraulic source for actuating a cylinder acting on the slide-wedge assembly.

20. The single gearbox of claim **17**, further comprising an electrical slip ring attached to an end of the sub-assembly, providing a point of connection for an external electrical source to the sub-assembly, the electrical source for powering a servo motor acting on the track drive.

21. The single gearbox of claim **17**, further comprising a servo drive on the gearbox casing for acting on gears and bearings in the end support to rotate the sub-assembly about the longitudinal axis.

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